

We claim:

1. A method of determining an uncoded bit error rate  $p_b$  based on a target symbol  
2 error rate  $\varepsilon_s$ , comprising:

3 determining the uncoded bit error rate  $p_b$  based on a weighted series expansion of  
4 the target symbol error rate  $\varepsilon_s$ , comprising weights W that are a function of a maximum  
5 number of symbol errors that can be corrected t and a number of symbols in an  
6 information field K; and

7 selecting the maximum number of symbol errors t and the number of symbols in  
8 the information field K such that the uncoded bit error rate  $p_b$  that produces a symbol  
9 error rate that is less than or equal to the target symbol error rate  $\varepsilon_s$  is largest.

1. 2. The method of claim 1 wherein the weighted series expansion comprises at least a  
first term, wherein second order and higher terms are ignored to determine the uncoded  
bit error rate  $p_b$ .

1. 3. The method of claim 1 wherein the symbols comprise Reed-Solomon symbols.

1. 4. The method of claim 1 wherein the weighted series expansion to determine the  
uncoded bit error  $p_b$  rate comprises the following relationship:

$$p_b = 1 - \left( 1 - W(t, K) \varepsilon_s^{\frac{1}{t+1}} \right)^{1/\alpha}$$

5  
6 wherein  
7

8       $W(t, K) = \left[ \binom{K+C+R-1}{t} \right]^{\frac{1}{(t+1)}},$

9  
10      $\varepsilon_s$  represents a target symbol error rate, and C + R represents a number of symbols in an  
11     error correction field.

1      5. A method of determining an optimum bit load per subchannel in a multicarrier  
2     system with forward error correction, comprising:

3        computing one or more values of a maximum number of symbol errors that  
4     can be corrected t, and a number of symbols in the information field K to determine  
5     the optimum bit load per subchannel in accordance with the following relationship:

6  
7       $1 - \left( 1 - W(t, K) \varepsilon_s^{\frac{1}{t+1}} \right)^{1/\alpha} = \omega(b) \left( 1 - 2^{-b(t,K)/2} \right) \operatorname{erfc} \left( \sqrt{3 \cdot 10^{7.10} / (2^{b(t,K)+1} - 2)} \right)$   
8       $\times \left[ 2 - \left( 1 - 2^{-b(t,K)/2} \right) \operatorname{erfc} \left( \sqrt{3 \cdot 10^{7.10} / (2^{b(t,K)+1} - 2)} \right) \right]$

9      wherein  $W(t, K) = \left[ \binom{K+C+R-1}{t} \right]^{\frac{1}{(t+1)}},$

10  
11       $\omega(b) = \frac{1}{b \cdot 2^b} \sum_{i=1}^b \sum_{j \neq i} \frac{d_H(a_i, a_j)}{\chi_i},$

12  
13      $\varepsilon_s$  represents a target symbol error rate, C + R represents a number of symbols in an  
14     error correction field, b represents a number of bit positions of a  
15     quadrature-amplitude-modulation symbol,  $\omega(b)$  represents an average fraction of  
16     erroneous bits in an erroneous b-sized quadrature-amplitude-modulation symbol,  $a_i$   
17     represents a label for the  $i^{\text{th}}$  point of a constellation associated with a subchannel,  $a_j$

18 represents a label for the  $j^{\text{th}}$  point of a constellation associated with a subchannel,  $\chi_i$   
19 represents a coordination number of the  $a_i^{\text{th}}$  point,  $d_H(a_i, a_j)$  represents a Hamming  
20 distance between respective binary vectors associated with points  $a_i$  and  $a_j$ ; and

21 selecting the maximum number of symbol errors that can be corrected  $t$ , and the  
22 number of symbols in the information field  $K$  such that the uncoded bit error rate  $p_b$  that  
23 produces a symbol error rate that is less than or equal to the target symbol error rate is  
24 increased.

1 6. A method of determining an optimum bit load per subchannel in a multicarrier  
2 system with forward error correction, comprising:

3 computing one or more values of a maximum number of symbol errors that  
4 can be corrected  $t$ , and a number of symbols in the information field  $K$  to determine  
5 the optimum bit load per subchannel in accordance with the following relationship:

$$1 - \left( 1 - W(t, K) \varepsilon_s^{\frac{1}{t+1}} \right)^{1/\alpha} = \omega(b) \left( 1 - 2^{-b_{\ell}(t, K)/2} \right) \operatorname{erfc} \left( \sqrt{3 \cdot 10^{r/10} / (2^{b_{\ell}(t, K)+1} - 2)} \right)$$
$$\times \left[ 2 - \left( 1 - 2^{-b_{\ell}(t, K)/2} \right) \operatorname{erfc} \left( \sqrt{3 \cdot 10^{r/10} / (2^{b_{\ell}(t, K)+1} - 2)} \right) \right]$$

$$\text{wherein } W(t, K) = \left[ \binom{K+C+R-1}{t} \right]^{\frac{1}{(t+1)}},$$

10  
11  $\varepsilon_s$  represents a target symbol error rate,  $C + R$  represents a number of symbols in an  
12 error correction field,  $b$  represents a number of bit positions of a  
13 quadrature-amplitude-modulation symbol,  $\omega(b)$  represents an approximate average  
14 fraction of erroneous bits in an erroneous  $b$ -sized quadrature-amplitude-modulation  
15 symbol; and

16           selecting the maximum number of symbol errors that can be corrected  $t$ , and the  
17       number of symbols in the information field  $K$  such that the uncoded bit error rate  $p_b$  that  
18       produces a symbol error rate that is less than or equal to the target symbol error rate is  
19       increased.

1       7.       The method of claim 6 wherein  $\omega(b_i)$  is determined in accordance with the  
2       following relationship:

3

4       
$$\omega(b_i) = \frac{4}{3 + 2b_i}$$

1       8.       A method of selecting forward error correction parameters in a channel having  
2       a plurality of subchannels in a multicarrier communications system, comprising:  
3           determining a signal-to-noise ratio representing a subset of the subchannels;  
4           and  
5           selecting forward error correction parameters of the channel based on the  
6       signal-to-noise ratio.

1       9.       The method of claim 8 wherein the subset of the subchannels comprises all of  
2       the subchannels of the channel.

1       10.      The method of claim 8 wherein the forward error correction parameters are  
2       utilized in Reed- Solomon encoding.

1       11.      The method of claim 8 wherein the signal-to-noise ratio is an average  
2       signal-to-noise ratio of respective signal-to-noise ratios of the subset of the  
3       subchannels.

1       12. The method of claim 8 wherein the signal-to-noise ratio represents all of the  
2       subchannels.

1       13. The method of claim 8 wherein the selecting comprises applying a mean field  
2       approximation to evaluate a bit load over the subset of subchannels.

1       14. The method of claim 13 wherein the selecting comprises adjusting the mean  
2       field approximation.

1       15. The method of claim 14 wherein the adjusting is applied when the number of  
2       bits per subchannel is less than or equal to two.

1       16. The method of claim 14 wherein the adjusting is a linear adjustment with  
2       respect to a bit load of a subchannel.

1       17. The method of claim 8 further comprising:  
2       determining the representative performance measurement as an average  
3       signal-to-noise ratio  $\gamma_{eff}$  for the channel in accordance with the following  
4       relationship:

5

6       
$$\gamma_{eff} = \frac{1}{n_{eff}} \sum_{\gamma_i > \gamma_s} \gamma_i, \text{ wherein}$$

7

8       
$$n_{eff} = \sum_{\gamma_i > \gamma_s} 1,$$

9

10        $\gamma_i$  represents a signal-to-noise measurement for an ith subchannel, and  $n_{eff}$   
11       represents a number of subchannels for which the signal-to-noise ratio  $\gamma_i$  was

12 measured for which  $\gamma_i$  is greater than  $\gamma_*$ , and  $\gamma_*$  represents a threshold  
13 signal-to-noise ratio.

1 18. A method of determining a bit load  $b$  per subchannel in a multicarrier system with  
2 forward error correction, comprising:

3 computing one or more values of a maximum number of symbol errors that  
4 can be corrected  $t$ , and a number of symbols in the information field  $K$  to determine  
5 the bit load per subchannel in accordance with the following relationship:

6

7  $b = [\gamma + \Phi(\gamma, t, K, \varepsilon)] / 10 \log 2$ ,

8

9 wherein

10  $\Phi(\gamma, t, K, \varepsilon)$

11  $= 10 \log \left[ 10^{-\gamma/10} + \frac{3 \log e}{2 \log \left[ \frac{\alpha \langle \omega(b) \rangle \sqrt{8/\pi}}{W(t, K)(\alpha \varepsilon / \beta)^{1/(t+1)}} \right] - \log \log \left[ \frac{\alpha \langle \omega(b) \rangle \sqrt{8/\pi}}{W(t, K)(\alpha \varepsilon / \beta)^{1/(t+1)}} \right] + \log \left( \frac{\log e}{2} \right)} \right]$

12 ,

13

14  $W(t, K) = \left[ \binom{K+C+R-1}{t} \right]^{\frac{1}{(t+1)}} \left[ \binom{K+C+R}{t+1} \right]^{\frac{k-1}{(t+1)}},$

15  $\langle \omega(b) \rangle = \frac{1}{b_{\max}} \int_1^{b_{\max}} \omega(b) (1 - 2^{-b/2}) db$

16  $\alpha$  represents a number of bits per symbol,  $\gamma$  represents a signal-to-noise ratio,  $t$   
17 represents a maximum number of symbol errors that can be corrected,  $\varepsilon$  represents a  
18 target bit error rate,  $C + R$  represents a number of symbols in an error correction field,

19        $b$  represents a number of bit positions of a quadrature-amplitude-modulation symbol,  
20        $\omega(b)$  represents an average fraction of erroneous bits in an erroneous  $b$ -sized  
21       quadrature-amplitude-modulation symbol,  $b_{max}$  is a maximum bit load per  
22       subchannel; and

23               selecting a bit load per subchannel in accordance with the maximum number  
24       of symbol errors that can be corrected  $t$ , and a number of symbols in the information  
25       field  $K$ .

1       19.      The method of claim 18 wherein  $\Phi(\gamma, t, K, \varepsilon)$  is evaluated at  $\gamma$  equals  $-\infty$ .

1       20.      The method of claim 18 wherein  $b$  is greater than or equal to three.

1       21.      A method of selecting forward error correction parameters for use in a channel  
2       having a plurality of subchannels, comprising:

3               determining an average signal-to-noise ratio of at least a subset of the  
4       subchannels; and

5               selecting forward error correction parameters based on the average signal-to-noise  
6       ratio, and a count of the number of subchannels in the subset.

1       22.      The method of claim 21 wherein the selecting the forward error correction  
2       parameters comprises selecting the forward error correction parameters based on a  
3       predicted gain from application of the selected forward error correction parameters.

1       23.      The method of claim 22 wherein the gain is a performance gain.

1        24. A method of selecting at least one forward error correction parameter,  
2 comprising:

3              computing one or more values representing a number of information symbols  
4 K in a frame accordance with the following relationship:

$$\begin{aligned} & \left[ \frac{\alpha(K+s+zs)}{sn_{\text{eff}}} + 1.5 \right] \left[ 1 - \left( 1 - \left( \left[ \binom{K+C+R-1}{t} \right]^{\frac{1}{t+1}} \varepsilon_s^{1/(t+1)} \right)^{1/\alpha} \right) \right] \\ & = 2 \left( 1 - 2^{-\frac{\alpha(K+s+zs)}{2sn_{\text{eff}}}} \right) \operatorname{erfc} \left( \sqrt{1.5 \cdot 10^{\gamma_{\text{eff}}/10} / \left( 2^{-\frac{\alpha(K+s+zs)}{sn_{\text{eff}}}} - 1 \right)} \right) \\ & \quad \times \left[ 2 - \left( 1 - 2^{-\frac{\alpha(K+s+zs)}{2sn_{\text{eff}}}} \right) \operatorname{erfc} \left( \sqrt{1.5 \cdot 10^{\gamma_{\text{eff}}/10} / \left( 2^{-\frac{\alpha(K+s+zs)}{sn_{\text{eff}}}} - 1 \right)} \right) \right] \end{aligned}$$

7        8 wherein  $t = \left\lfloor \frac{sz+1+e_r}{2} \right\rfloor$ ,  $e_r \leq sz$ , and

9  
10      s represents a number of discrete multi-tone symbols in a frame, z represents a  
11      number of error correction symbols in a discrete multi-tone symbol,  $\alpha$  represents a  
12      number of bits per code symbol, C+R represents a number of redundant symbols in  
13      an error correction field,  $n_{\text{eff}}$  represents a number of subchannels exceeding a  
14      threshold performance value,  $\gamma_{\text{eff}}$  represents an effective signal-to-noise ratio  
15      associated with the number of subchannels exceeding the threshold performance  
16      value,  $\varepsilon_s$  represents a target symbol error rate; and  $e_r$  represents a number of erasures;  
17      and

18              determining a number of bits per subchannel in accordance with the one or  
19      more values of K.

1       25. The method of claim 24 wherein  $K$  is a continuous variable.

1       26. The method of claim 24 wherein  $K$  is computed using dichotomy, for values  
2       of  $\gamma_{eff}$ ,  $n_{eff}$ ,  $z$ , and  $s$ .

1       27. The method of claim 24 further comprising:

2              determining a net coding gain associated with values of  $\gamma_{eff}$ ,  $n_{eff}$ ,  $z$ , and  $s$ ;  
3              determining an incremental number of bits per subchannel associated with the  
4       net coding gain; and  
5              storing associated values of  $\gamma_{eff}$ ,  $n_{eff}$ ,  $z$ ,  $s$  and the incremental number of bits  
6       per subchannel.

1       28. A method of selecting transmission parameters of a multicarrier system  
2       having a channel comprising a plurality of subchannels, comprising:

3              selecting a number ( $s$ ) of discrete multi-tone symbols in a  
4       forward-error-correction frame, and a number ( $z$ ) of forward-error-correction control  
5       symbols in a discrete multitone symbol based on a signal-to-noise ratio and a number  
6       of subchannels associated with the signal-to-noise ratio; and  
7              transmitting information in accordance with the selected number ( $s$ ) of  
8       discrete multi-tone symbols, and a number ( $z$ ) of forward-error-correction control  
9       symbols in the discrete multitone symbol.

1       29. The method of claim 28 wherein the selecting comprises selecting an  
2       adjustment value per subchannel based on the signal-to-noise ratio and the number of  
3       subchannels associated with the signal-to-noise ratio; and

4              adjusting a number of bits per subchannel for at least one subchannel in  
5       accordance with the adjustment value.

30. The method of claim 28 wherein the signal-to-noise ratio is an average signal-to-noise ratio of the associated number of subchannels.

31. The method of claim 28 further comprising:

storing, in a table, the number ( $s$ ) of discrete multi-tone symbols in the forward-error-correction frame, the number ( $z$ ) of forward-error-correction control symbols in the discrete multitone symbol associated with the signal-to-noise ratio and the number of subchannels associated with the signal-to-noise ratio, for different values of  $s$ ,  $z$ , signal-to-noise ratios and numbers of subchannels.

32. The method of claim 31 wherein for each value of signal-to-noise ratio and number of bits per subchannel of the table, the associated value of s and z provide a maximal net coding gain  $g_n$ , and the associated value of s and z is selected from a subset of associated s and z values.

33. An apparatus for determining an uncoded bit error rate  $p_b$  based on a target symbol error rate  $\varepsilon_s$ , comprising:

means for determining the uncoded bit error rate  $p_b$  based on a weighted series expansion of the target symbol error rate  $\varepsilon_s$ , comprising weights  $W$  that are a function of a maximum number of symbol errors that can be corrected  $t$  and a number of symbols in an information field  $K$ ; and

means for selecting the maximum number of symbol errors  $t$  and the number of symbols in the information field  $K$  such that the uncoded bit error rate  $p_b$ , that produces a symbol error rate that is less than or equal to the target symbol error rate  $\varepsilon_s$ , is largest.

34. The apparatus of claim 33 wherein the weighted series expansion comprises at least a first term, wherein second order and higher terms are ignored to determine the uncoded bit error rate  $p_b$ .

1       35. The apparatus of claim 33 wherein the symbols comprise Reed-Solomon symbols.

1       36. The apparatus of claim 33 wherein the weighted series expansion to determine the  
2       uncoded bit error  $p_b$  rate comprises the following relationship:

4

$$p_b = 1 - \left( 1 - W(t, K) \varepsilon_s^{\frac{1}{t+1}} \right)^{1/\alpha}$$

5       wherein

8

$$W(t, K) = \left[ \binom{K+C+R-1}{t} \right]^{\frac{1}{(t+1)}},$$

10       $\varepsilon_s$  represents a target symbol error rate, and C + R represents a number of symbols in  
11     an error correction field.

1       37. An apparatus for determining an optimum bit load per subchannel in a  
2       multicarrier system with forward error correction, comprising:

3       means for computing one or more values of a maximum number of symbol  
4       errors that can be corrected t, and a number of symbols in the information field K to  
5       determine the optimum bit load per subchannel in accordance with the following  
6       relationship:

8

$$1 - \left( 1 - W(t, K) \varepsilon_s^{\frac{1}{t+1}} \right)^{1/\alpha} = \omega(b) \left( 1 - 2^{-b(t,K)/2} \right) \operatorname{erfc} \left( \sqrt{3 \cdot 10^{y_t/10} / (2^{b(t,K)+1} - 2)} \right)$$
$$\times \left[ 2 - \left( 1 - 2^{-b(t,K)/2} \right) \operatorname{erfc} \left( \sqrt{3 \cdot 10^{y_t/10} / (2^{b(t,K)+1} - 2)} \right) \right]$$

10           wherein  $W(t, K) = \left[ \binom{K+C+R-1}{t} \right]^{\frac{1}{(t+1)}}$ ,

11  
12            $\omega(b) = \frac{1}{b \cdot 2^b} \sum_{i=1}^b \sum_{j \neq i} \frac{d_H(a_i, a_j)}{\chi_i}$ ,

13  
14          $\varepsilon_s$  represents a target symbol error rate, C + R represents a number of symbols in an  
15         error correction field, b represents a number of bit positions of a  
16         quadrature-amplitude-modulation symbol,  $\omega(b)$  represents an average fraction of  
17         erroneous bits in an erroneous b-sized quadrature-amplitude-modulation symbol,  $a_i$   
18         represents a label for the  $i^{\text{th}}$  point of a constellation associated with a subchannel,  $a_j$   
19         represents a label for the  $j^{\text{th}}$  point of a constellation associated with a subchannel,  $\chi_i$   
20         represents a coordination number of the  $a_i^{\text{th}}$  point,  $d_H(a_i, a_j)$  represents a Hamming  
21         distance between respective binary vectors associated with points  $a_i$  and  $a_j$ ; and

22         means for selecting the maximum number of symbol errors that can be  
23         corrected t, and the number of symbols in the information field K such that the  
24         uncoded bit error rate  $p_b$  that produces a symbol error rate that is less than or equal to  
25         the target symbol error rate is increased.

1         38. An apparatus for determining an optimum bit load per subchannel in a  
2         multicarrier system with forward error correction, comprising:

3         means for computing one or more values of a maximum number of symbol  
4         errors that can be corrected t, and a number of symbols in the information field K to  
5         determine the optimum bit load per subchannel in accordance with the following  
6         relationship:

8

$$1 - \left( 1 - W(t, K) e_s^{\frac{1}{t+1}} \right)^{1/\alpha} = \omega(b) \left( 1 - 2^{-b_i(t, K)/2} \right) \operatorname{erfc} \left( \sqrt{3 \cdot 10^{r/10} / (2^{b_i(t, K)+1} - 2)} \right)$$

9

$$\times \left[ 2 - \left( 1 - 2^{-b_i(t, K)/2} \right) \operatorname{erfc} \left( \sqrt{3 \cdot 10^{r/10} / (2^{b_i(t, K)+1} - 2)} \right) \right]$$

10

$$\text{wherein } W(t, K) = \left[ \binom{K+C+R-1}{t} \right]^{\frac{1}{(t+1)}}.$$

11

12  $\epsilon_s$  represents a target symbol error rate, C + R represents a number of symbols in an  
13 error correction field, b represents a number of bit positions of a  
14 quadrature-amplitude-modulation symbol,  $\omega(b)$  represents an approximate average  
15 fraction of erroneous bits in an erroneous b-sized quadrature-amplitude-modulation  
16 symbol; and

17 selecting the maximum number of symbol errors that can be corrected t, and  
18 the number of symbols in the information field K such that the uncoded bit error rate  
19  $p_b$  that produces a symbol error rate that is less than or equal to the target symbol  
20 error rate is increased.

1 39. The apparatus of claim 38 wherein  $\omega(b_i)$  is determined in accordance with the  
2 following relationship:

3

4 
$$\omega(b_i) = \frac{4}{3 + 2b_i}$$

1 40. An apparatus for selecting forward error correction parameters in a channel  
2 having a plurality of subchannels in a multicarrier communications system,  
3 comprising:

4           means for determining a signal-to-noise ratio representing a subset of the  
5        subchannels; and

6           means for selecting forward error correction parameters of the channel based  
7        on the signal-to-noise ratio.

1       41.   The apparatus of claim 40 wherein the subset of the subchannels comprises all  
2        of the subchannels of the channel.

1       42.   The apparatus of claim 40 wherein the forward error correction parameters are  
2        utilized in Reed-Solomon encoding.

1       43.   The apparatus of claim 40 wherein the signal-to-noise ratio is an average  
2        signal-to-noise ratio of respective signal-to-noise ratios of the subset of the  
3        subchannels.

1       44.   The apparatus of claim 40 further comprising:  
2           means for determining a signal-to-noise ratio representing all of the  
3        subchannels.

1       45.   The apparatus of claim 40 wherein the means for selecting comprises means  
2        for applying a mean field approximation to evaluate a bit load over the subset of  
3        subchannels.

1       46.   The apparatus of claim 40 wherein the means for selecting comprises means  
2        for adjusting the mean field approximation.

1       47.   The apparatus of claim 46 wherein the means for adjusting is applied when  
2        the number of bits per subchannel is less than or equal to two.

1       48. The apparatus of claim 46 wherein the means for adjusting is a linear  
2       adjustment with respect to a bit load of a subchannel.

1       49. The apparatus of claim 46 further comprising:  
2           means for determining the representative performance measurement as an  
3           average signal-to-noise ratio  $\gamma_{eff}$  for the channel in accordance with the following  
4           relationship:

5

$$6 \quad \gamma_{eff} = \frac{1}{n_{eff}} \sum_{\gamma_i > \gamma_*} \gamma_i, \text{ wherein}$$

7

$$8 \quad n_{eff} = \sum_{\gamma_i > \gamma_*} 1,$$

9

10       $\gamma_i$  represents a signal-to-noise ratio measurement for an ith subchannel, and  $n_{eff}$   
11     represents a number of subchannels for which the signal-to-noise ratio  $\gamma_i$  was  
12     measured for which  $\gamma_i$  is greater than  $\gamma_*$ , and  $\gamma_*$  represents a threshold  
13     signal-to-noise ratio.

1       50. The apparatus of claim 49 further comprising:  
2           means for determining the representative performance measurement as an  
3           average signal-to-noise ratio  $\gamma_{eff}$  for the channel in accordance with the following  
4           relationship:

5

$$6 \quad \gamma_{eff} = \frac{1}{n_{eff}} \sum_{\gamma_i > \gamma_*} \gamma_i, \text{ wherein}$$

8       $n_{\text{eff}} = \sum_{\gamma_i \geq \gamma_*} 1,$

9

10      $\gamma_i$  represents a signal-to-noise measurement for an  $i$ th subchannel, and  $n_{\text{eff}}$  represents  
11    a number of subchannels for which the signal-to-noise ratio  $\gamma_i$  was measured for  
12    which  $\gamma_i$  is greater than or equal to than  $\gamma_*$ , and  $\gamma_*$  represents a threshold  
13    signal-to-noise ratio.

1      51. An apparatus for determining a bit load  $b$  per subchannel in a multicarrier system  
2    with forward error correction, comprising:

3      means for computing one or more values of a maximum number of symbol  
4    errors that can be corrected  $t$ , and a number of symbols in the information field  $K$  to  
5    determine the bit load per subchannel in accordance with the following relationship:

6

7       $b = [\gamma + \Phi(\gamma, t, K, \varepsilon)]/10 \log 2 ,$

8

9      wherein

10

11       $\Phi(\gamma, t, K, \varepsilon)$

12       $= 10 \log \left\{ 10^{-\gamma/10} + \frac{3 \log e}{2 \log \left[ \frac{\alpha(\omega(b)) \sqrt{8/\pi}}{W(t, K)(\alpha\varepsilon/\beta)^{\frac{1}{t+1}}} \right] - \log \log \left[ \frac{\alpha(\omega(b)) \sqrt{8/\pi}}{W(t, K)(\alpha\varepsilon/\beta)^{\frac{1}{t+1}}} \right] + \log \left( \frac{\log e}{2} \right)} \right\}$

13

14

$$W(t, K) = \left[ \binom{K+C+R-t}{t+1} \right]^{\frac{1}{t+1}} \left[ \binom{K+C+R}{t+1} \right]^{\frac{k-t}{t+1}},$$

15           
$$\langle \omega(b) \rangle = \frac{1}{b_{\max}} \int_1^{b_{\max}} \omega(b)(1 - 2^{-b/2}) db$$

16

17        $\alpha$  represents a number of bits per symbol,  $\gamma$  represents a signal-to-noise ratio,  $t$   
18       represents a maximum number of symbol errors that can be corrected,  $\epsilon$  represents a  
19       target bit error rate,  $C + R$  represents a number of symbols in an error correction field,  
20        $b$  represents a number of bit positions of a quadrature-amplitude-modulation symbol,  
21        $\omega(b)$  represents an average fraction of erroneous bits in an erroneous  $b$ -sized  
22       quadrature-amplitude-modulation symbol,  $b_{\max}$  is a maximum bit load per  
23       subchannel; and

24           means for selecting a bit load per subchannel in accordance with the  
25       maximum number of symbol errors that can be corrected  $t$ , and a number of symbols  
26       in the information field  $K$ .

1       52.      The apparatus of claim 51 wherein  $\Phi(\gamma, t, K, \epsilon)$  is evaluated at  $\gamma$  equals  $-\infty$ .

1       53.      The apparatus of claim 51 wherein  $b$  is greater than or equal to three.

1       54.      An apparatus for selecting forward error correction parameters for use in a  
2       channel having a plurality of subchannels, comprising:

3           means for determining an average signal-to-noise ratio of at least a subset of the  
4       subchannels; and

5           means for selecting forward error correction parameters based on the average  
6       signal-to-noise ratio, and a count of the number of subchannels in the subset.

1       55.      The apparatus of claim 54 wherein the means for selecting the forward error  
2       correction parameters selects the forward error correction parameters based on a  
3       predicted gain from application of the selected forward error correction parameters.

1        56. The apparatus of claim 55 wherein the gain is a performance gain.

1        57. An apparatus for selecting at least one forward error correction parameter,  
2 comprising:  
3              means for computing one or more values representing a number of  
4 information symbols K in a frame accordance with the following relationship:

$$\begin{aligned} & \left[ \frac{\alpha(K+s+zs)}{sn_{eff}} + 1.5 \right] \left[ 1 - \left( 1 - \left( \left[ \binom{K+C+R-1}{t} \right]^{\frac{1}{(t+1)}} \varepsilon_s^{1/(t+1)} \right)^{1/\alpha} \right) \right] \\ & = 2 \left( 1 - 2^{-\frac{\alpha(K+s+zs)}{2sn_{eff}}} \right) erfc \left( \sqrt{1.5 \cdot 10^{\gamma_{eff}/10} \left( 2^{-\frac{\alpha(K+s+zs)}{sn_{eff}}} - 1 \right)} \right) \\ & \quad \times \left[ 2 - \left( 1 - 2^{-\frac{\alpha(K+s+zs)}{2sn_{eff}}} \right) erfc \left( \sqrt{1.5 \cdot 10^{\gamma_{eff}/10} \left( 2^{-\frac{\alpha(K+s+zs)}{sn_{eff}}} - 1 \right)} \right) \right] \end{aligned}$$

7        8        wherein  $t = \left\lfloor \frac{sz + 1 + e_r}{2} \right\rfloor$ ,  $e_r \leq sz$ , and

9        10       s represents a number of discrete multi-tone symbols in a frame, z represents a  
11       number of error correction symbols in a discrete multi-tone symbol,  $\alpha$  represents a  
12       number of bits per code symbol, C+R represents a number of redundant symbols in  
13       an error correction field,  $n_{eff}$  represents a number of subchannels exceeding a  
14       threshold performance value,  $\gamma_{eff}$  represents an effective signal-to-noise ratio  
15       associated with the number of subchannels exceeding the threshold performance  
16       value,  $\varepsilon_s$  represents a target symbol error rate; and  $e_r$  represents a number of erasures;

17       and

18       means for determining a number of bits per subchannel in accordance with the  
one or more values of K.

1        58. The apparatus of claim 57 wherein  $K$  is a continuous variable.

1        59. The apparatus of claim 57 wherein  $K$  is computed using dichotomy, for values  
2        of  $\gamma_{eff}$ ,  $n_{eff}$ ,  $z$ , and  $s$ .

1        60. The apparatus of claim 57 further comprising:  
2              means for determining a net coding gain associated with values of  $\gamma_{eff}$ ,  $n_{eff}$ ,  $z$ ,  
3              and  $s$ ;  
4              means for determining an incremental number of bits per subchannel  
5              associated with the net coding gain; and  
6              means for storing associated values of  $\gamma_{eff}$ ,  $n_{eff}$ ,  $z$ ,  $s$  and the incremental  
7              number of bits per subchannel.

1        61. An apparatus for selecting transmission parameters of a multicarrier system  
2        having a channel comprising a plurality of subchannels, comprising:  
3              means for selecting a number ( $s$ ) of discrete multi-tone symbols in a  
4              forward-error-correction frame, and a number ( $z$ ) of forward-error-correction control  
5              symbols in a discrete multitone symbol based on a signal-to-noise ratio and a number  
6              of subchannels associated with the signal-to-noise ratio; and  
7              means for transmitting information in accordance with the selected number ( $s$ )  
8              of discrete multi-tone symbols, and a number ( $z$ ) of forward-error-correction control  
9              symbols in the discrete multitone symbol.

1        62. The apparatus of claim 61 wherein the means for selecting comprises:  
2              selecting an adjustment value per subchannel based on the signal-to-noise  
3              ratio and the number of subchannels associated with the signal-to-noise ratio; and  
4              means for adjusting a number of bits per subchannel for at least one  
5              subchannel in accordance with the adjustment value.

1       63. The apparatus of claim 61 wherein the signal-to-noise ratio is an average  
2                   signal-to-noise ratio of the associated number of subchannels.

1       64. The apparatus of claim 61 further comprising:  
2                   means for storing, in a table, the number (s) of discrete multi-tone symbols in  
3                   the forward-error-correction frame, the number (z) of forward-error-correction  
4                   control symbols in the discrete multitone symbol associated with the signal-to-noise  
5                   ratio and the number of subchannels associated with the signal-to-noise ratio, for  
6                   different values of s, z, signal-to-noise ratios and numbers of subchannels.

1       65. The apparatus of claim 64 wherein for each value of signal-to-noise ratio and  
2                   number of bits per subchannel of the table, the associated value of s and z provides a  
3                   maximal net coding gain, and the associated value of s and z is selected from a subset  
4                   of associated s and z values.